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SUMMARY OF CONFERENCE ON RESEARCH NEEDS IN
ENVIRONMENTAL HEALTH HELD AT ATLANTA, GEORGIA ON
JANUARY 28-29, 1964

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ENVIRONMENTAL PROTECTION AGENCY
2nd Conference
Region IV Research Development

*Research Needs
in
Environmental
Health*

JANUARY 28-29, 1964
Academy of Medicine
875 W. Peachtree Street, N.E.
Atlanta, Georgia



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SUMMARY OF CONFERENCE
ON
RESEARCH NEEDS IN ENVIRONMENTAL HEALTH

ATLANTA, GEORGIA
January 28-29, 1964

SPONSORED BY

THE PUBLIC HEALTH SERVICE REGION IV
RESEARCH DEVELOPMENT OFFICE

AND

REGIONAL PROGRAM DIRECTORS FOR
ENVIRONMENTAL HEALTH SERVICES

PREFACE

One of the objectives of the Region IV Research Development Office is to hold annual research development conferences for the purpose of bringing together those who have common research interests in areas where emphasis is needed. This affords a group the opportunity to increase research potentials through better understanding of current problems, better communications and sharing ideas.

Consequently, the objective of this conference was to stimulate current and potential investigators in more creative environmental health research and to provide a better understanding of the concept of environmental health and the interrelationships in research.

Guest speakers of exceptional competence presented papers covering research interests in the areas of air pollution, occupational health, food, radiological health, water and solid wastes.

Those attending had special environmental research interests in these areas which encompassed medicine, sanitary engineering, and the biological and physical sciences.

Note: Throughout this document summaries, where feasible, are given of the formal papers, discussant papers and also the general discussion sessions.

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OPENING REMARKS

The second Region IV Research Development Conference opened with several introductory comments from the Chairman, Mr. H. W. Chapman, Associate Regional Health Director for Environmental Health, concerning needs as expressed by several investigators throughout Region IV for bringing the group together, sharing ideas and, in general, to strive to increase the potentials in environmental health research. Dr. H. B. Cottrell, Regional Health Director, was then introduced and pointed out the historical relationship of the present conference with those of previous years. He mentioned that the conference method has proven highly successful in improving communications between staff and research investigators throughout Region IV of the Public Health Service.

RESEARCH NEEDS IN ENVIRONMENTAL HEALTH SCIENCES
Mr. Frank Butrico

The extramural grants program in environmental health came into being a few years ago when funds were transferred from the National Institutes of Health to the Bureau of State Services (Environmental Health). The funds were divided among the five categorical programs on the basis of on-going supported projects. The five categorical divisions are: Water Supply and Pollution Control, Air Pollution, Occupational Health, Environmental Engineering and Food Protection, and Radiological Health.

The Bureau is continuing to use the administrative services at National Institutes of Health and for this reason all research applications are being sent to the Division of Research Grants. Over the past year the role of that office has been expanded to provide Service-wide administrative services in connection with the extramural grants program.

The Division of Research Grants is responsible for the preliminary (scientific) review of research proposals, including those in environmental health. Secondary review is provided by a newly formed National Advisory Environmental Health Committee with final decision on payment of specific research proposals made by our categorical divisions.

There is a sixth research and training grants support program in the Bureau under the title of Environmental Health Sciences which Dr. William Upholt will discuss later.

There have been a number of studies on research and training needs in environmental health. One of the most noteworthy being the Report of the Committee on Environmental Health Problems, commonly known as the "Gross Report". On training needs there is the Conference on Educational Needs in Environmental Health.

A variety of extramural research and training grants support programs in environmental health were reviewed briefly.

For the most part, the broad training grant activities in environmental health are for training at the graduate level. In FY 1965 the Division of Radiological Health will, in addition, initiate a technician training program.

In each of the categorical areas previously mentioned there are training grant funds available to assist graduate schools in improving research competency. They provide for faculty additions, pre-master's and pre and post-doctoral student stipends and tuition, guest lecturers, essential laboratory equipment, modest renovation of facilities, and certain travel costs.

The grants are primarily to assist departments in upgrading or initiating new research and doctoral-level programs, to broaden and intensify their interests in more challenging research and training areas, and to produce more highly trained graduates.

In Air and Water Pollution Control, the training grant programs also include general support for broad curricula development in these specialities.

With respect to support of individuals, the environmental health units in the Public Health Service made available grants for traineeships and fellowships. Some are made directly by the Service and others through a special purpose training grant to an academic institution or general purpose traineeship grants to schools of public health.

The special purpose program provides block grants to institutions to cover stipends and tuition fees of students who wish to enroll in full-time graduate or specialized training courses in the environmental health area. The grants can be used to supply the means by which outstanding students in engineering and the basic sciences may be attracted into the health field.

Flexibility of the program is such that any level of graduate training from the pre-master to the post-doctoral level can be supported as well as non-degree training in high priority areas. This type of grant provides only for support of students, and the selection of the individual trainee is the responsibility of the school.

Block grants are provided also to the eleven (11) approved schools of public health only to cover stipends and tuition fees of full-time graduate students enrolled in those schools. Trainees are selected by the schools and may include students enrolled there in environmental health courses.

In addition, there are regular fellowships which include three types of direct awards: pre and post-doctoral, and special fellowships.

These grants are made to support the training of highly qualified scholars who are primarily interested in pursuing research and academic careers in the environmental health sciences. They are aimed at increasing basic scientific competence and encouraging interdisciplinary study in the various fields of interest in environmental health.

Dr. Upholt will now discuss the Environmental Health Sciences research and training grants program.

RESEARCH NEEDS IN THE ENVIRONMENTAL HEALTH SCIENCES
(Research Grants Program)
William M. Upholt, Ph.D.

Environmental Health Sciences Research Grants Program is the most recent of the research grants programs to be established. It arose out of a need for a mechanism for supporting applications which are definitely environmental health but which do not fit into any one of the categorical divisions.

In the short time available, I will mention only two examples of areas of great need to be supported under this category. Perhaps the best illustration arises out of the statement made by the subcommittee in recommending the establishment of this new program to the Appropriations Committee of the House of Representatives for FY-64. Paraphrasing the statement, it is that a better understanding of biological changes resulting from exogenous chemical and physical forces may well be the most important factor in the continued existence of human life on this planet. This is a strong statement but it emphasizes the need for us to learn more about the effects of these factors in the environment on the basic functioning of the organism.

The committee further suggested that the solution of this problem will probably require the establishment of a new discipline incorporating some of the features of pharmacology and toxicology but not identical with either of the disciplines in the traditional sense. More specifically, it is not sufficient to know the level

of mortality produced by gross exposure to chemicals but rather we need to know the effects, often subtle or even subliminal, resulting from long continued exposure to every low concentrations. Thus, understanding of reactions at a sub-cellular level is important not only to the immediate organism but even into future generations.

An understanding of the effects upon growth regulators, on RNA and DNA, and other important molecules of this sort are examples of the type of fundamental studies that we desperately need.

I will mention a second example at the other end of the spectrum. It is based on the concept that environmental health control programs depend, for their success, upon an understanding and acceptance by the general public. We can not expect the public to accept and defend pollution control programs unless they understand what is at stake and the cost of the program. It seems essential therefore that we learn how to communicate the principles and the significance of them from the technical source upon which control programs are based, down through the various levels of supervision and administration, to the members of the general public who are contacted by the sanitarians and other agency personnel who are responsible for carrying out the programs.

Thus we need to support research in sociological sciences which will permit us to more effectively communicate the rationale for control programs to the public. This research must not be based

upon a "Madison Avenue" approach of super salesmanship but rather upon the faith, which I have but which some of you may not share, that the general public is intelligent and will make intelligent decisions if they are given adequate information upon which to base them.

I could give you many other examples of research needs in environmental health sciences which could be classified in entirely different ways. For instance, the current wide-spread interest in pesticides cuts across the classification system I have just suggested and within this one problem area, we can well justify research involving both basic toxicology-pharmacology and also sociological acceptance, and much of this research will be independent of the route of exposure (air, water or food).

These are but a few examples but should give you some idea of what we mean by non-categorical environmental health research which will be supported by the Environmental Health Sciences program rather than one of the five Divisions about which you will be hearing more during this conference.

RESEARCH NEEDS IN AIR POLLUTION
Mr. Arthur C. Stern

The research needs in air pollution are enumerated as: What pollutants are in the air?; What do they do?; What are their sources?; How are they transported and concentrated?; What can we do to reduce them? It was pointed out a great amount of knowledge has been accumulated in a relatively short time, but there still remains many gaps in our knowledge. Research work is being done in the gap areas at the cost of approximately \$22 million per year. Both ongoing research and gap areas have been cataloged several times during the past decade.

With regard to what is in the air, a large percentage of the components were identified early, but it becomes more difficult to identify and quantitate the numerous compounds that are liquid or solid at atmospheric temperature and pressure conditions. A start has been made in this field but there is much work yet to be done. Another and more difficult task is the elucidation of the physical form, distribution, size, shape, porosity, solubility and electrical properties. All of this is necessary to understand the fate of these compounds with regard to reaction, removal, and effects on humans, animals and vegetation. Another task is to differentiate the particles above and below the haze layer. Only a start has been made in studying the reactions of compounds in real and synthetic atmospheres.

With respect to what do they do, it was pointed out that most research has been concerned with effects of air pollution on animals and vegetation because it is easier to study. There is a need for further research in all areas of air pollution effects. The difficulties involved in retrospective studies of air pollution and human health were enumerated. Research needs to be done on the mechanism of air pollution injury to biological systems. There is a great need for air quality standards based primarily on human health considerations.

With regard to what are the sources, it was pointed out that studies made years ago provided very little information. Many industrial source emissions were either unmeasured or were trade secrets. Today's approach to setting emission standards requires a great deal of knowledge of sources and emission rates. More detailed studies are needed to relate the specific components of the emissions to the problem to be abated.

To study how air pollutants are transported and concentrated involved meteorology which is also developing along pioneer paths. Meteorological service years ago were geared to agricultural needs but during the past thirty years they have been geared to meet aviation needs and in the future they will need to be correlated to urban population needs. Research is needed to develop the equipment and methods for urban meteorological services.

Two general research needs are indicated in the area of what can be done to reduce air pollution; (1) development of general

purpose control equipment and (2) the solution of special problems. It is argued that government and the academic community should not operate in this area but rather that industry should solve this problem. This would be failing the American public because there will be no answer when industry says that the air pollution control technology of yesterday is the best that can be offered today. Who but government and universities is to do research on the pollution producing activities operated by the public such as home heating and community refuse disposal. To obtain improvement in air pollution control equipment, collaboration of governmental and university research efforts are needed. The most important special problem of today are reduction of hydrocarbon emissions from automobiles, sulfur emissions from fuel burning and oxide of nitrogen emissions from combustion processes.

These are some of the areas needing more research attention. Other special areas of need include: (1) the development of better methods of assessing the economic burden of air pollution on our society, (2) better methods of advising the public of existing and potential adverse environmental health situations, (3) need to evaluate the overall impact that air pollution control measures will have, and (4) the inclusion of air resource management in urban planning and development.

In this field, as in others we must meet the responsibility of translating the fruits of research into a better and more healthful environment.

DISCUSSANT
Dr. E. R. Hendrickson

Research in air pollution is not as far behind schedule as some people think. Numerous reports have been prepared during the past 10 years to show the specific research projects that are needed. The experience of preparing a list of research needs is frustrating, especially if the list is reviewed several years later and one finds about half of the projects still need to be done. Most of this is probably due to the lack of personnel and time to do the work.

Great strides have been made in air pollution research and a great deal has been learned but it is disconcerting to find that the key solution to a specific problem is to be found in a research project suggested as necessary years ago and yet no one has been working on it. We don't have 50 years to obtain the necessary answers, strong pressures are on us to find the answers now.

The real need in air pollution research is the lack of qualified researchers who are interested in the field. Many disciplines are needed for investigation of air pollution problems and many of these can devote only a minor effort because they have long standing problems of their own to solve. In addition, in some of these disciplines we are competing with the glamour fields, such as polio, cancer, and the space program.

Air pollution is not the only field that is faced with a shortage of research personnel. There is an apparent need to advertise our programs in terms of what we are doing for the public and what needs to be done. The present situation leads to the inefficient use of scientifically trained personnel.

One area of research needs is the development of ambient air quality standards. Most present regulations are arbitrary with no relationship to the number of sources or the effect on our environment. More and more the emitters are questioning the basis on which they are being required to reduce emissions. This can be answered only when we know that a certain contaminant concentration will produce a certain undesirable effect on the environment. Eventually air quality standards will also have to consider synergistic effects rather than the effects of a single isolated pollutant. There is some confusion about setting standards and the application of standards. The setting of air quality standards is mainly a scientific decision whereas applying them is a political decision. Air quality standards must be related to sources which will require meteorological research so that appropriate dispersion calculations can be made. To develop and apply sound air quality standards will require a coordinated research effort.

There are probably sufficiently trained scientists to develop data for the human health effects for a few of our most common pollutants but to go beyond this point will require scientific personnel capabilities beyond our present numbers. Efforts are

being made to increase the number of trained scientific researchers but it is up to the people working in the field to provide proper environment and encouragement to insure that the necessary number of research personnel are available when needed.

GENERAL DISCUSSION

A question was raised about using non-engineering personnel who would be trained on the job and the availability of cheap, accurate, automatic air monitoring equipment.

It was pointed out that the Division of Radiological Health has started a pioneer project of training technicians for two years in junior colleges to increase the supply of trained personnel to perform many functions that do not require a person with full professional training. This pioneer project may indicate whether such an approach would be feasible for training air pollution technicians.

It was agreed that there is a definite need for cheap, accurate, automatic air monitoring equipment but this equipment is very complex and will probably continue to be expensive to install and operate. One solution may be to have a few pieces of the equipment on a mobile basis and thus cover many different locations.

Another question was raised about the availability of trained personnel for the junior colleges to train the needed technicians. The answer indicated that adequate salaries were also a part of the problem with the availability of trained personnel and there were several approaches that could be used to train additional personnel including universities, PHS training facilities as well as specific on the job training.

A question was also asked regarding the availability of an accurate, up to date log of research that needs to be done in the

various segments of environmental health. The reply indicated that such information was not available in any one location at the present time. It was also reported that responsibility has recently been delegated to the Public Health Service Division of Air Pollution to set-up and operate a Technical Information Office for abstracting, translating, storage and retrieval of air pollution literature.

A question was raised regarding the enforcement authority of the new Clean Air Act. The reply outlined the procedure for interstate enforcement actions and that nothing could be done on intrastate air pollution problems if the State does not choose to engage in enforcement activities.

A question was raised as to the status of the new Clean Air Act. The reply indicated that preparations were being made to implement the new authorities of the act but none have yet been placed in operation. This is anticipated on or about June 1, 1964.

OCCUPATIONAL HEALTH
Dr. D. H. K. Lee

People sometimes ask why further research is needed in Occupational Health, pointing out that the many dramatic incidents in the past were investigated and presumably solved, and all that needs to be done now is to apply this knowledge. It's quite true that these dramatic incidents seldom occur now and that when they do occur it is due to individual rather than medical ignorance. But we now find ourselves up against the operation of factors which are less understood, more subtle in their action, more continuous, and for the most part cumulative in their effects. This field calls for considerably more, deeper and wider types of research than were necessary in the past. Industry itself has also changed, is changing, and will continue to change. New processes are being introduced, new substances made, and new uses found for old substances. The climate of the work place is being radically altered. People have changed too! Twenty or twenty-five years ago people didn't complain very much about lighting, heat, smells, or noise, they took these things more or less for granted. Today the odds are that you won't hire or keep a work force if you don't tend to these things. The acceptance level has considerably changed. If you were an employer whose plant did not have air conditioning, while the plant across the road did, you know who would have the labor problem. It is no longer a question of physiological requirement but one of social satisfaction.

Occupational Health has a very wide range. There is hardly a medical science that is not involved at some time. At one end of this wide spectrum is research or industry itself. Where is industry going? What changes are being made in process or methods? What new materials or intermediates are likely to come along? If we had had adequate intelligence about the development of pesticides five years before they were used on a wide scale, we might have been in a better position than we are today. We do not have a proper intelligence of where industry is going. Research requires a long lead-time. It is not very effective to wait for the problem to get acute before starting the research to solve it. Sometimes we get in early, as with the question of possible toxicity of new beryllium ores; but this is rather exceptional at the moment.

A long-time feature of the occupational health spectrum is toxicology. Some 500 new substances of potential toxicity are said to be added to industry's armamentarium every year. In many cases the substance belongs to a class with which we are already familiar, and we can take a pretty good guess at what the toxicity is likely to be. The others should be looked at, but the investigation of any one substance involves quite a bit of work, and may tie up at least one exposure chamber for periods ranging up to two years. One has to pick and choose, selecting those which are most likely to be important or which are going to have the widest use. Toxicology tries to be quantitative. It likes to say that concentration of such and such in the air or water or food should never be exceeded or should not be permitted if the person is going to be exposed to

it eight hours a day. This is a perfectly legitimate objective and figures are devised and published with due warning that these figures are simply based on the best evidence available now, that they are not absolute figures. They usually include a safety factor like the one an engineer puts into his design. People tend, however, to use the figures as absolute values and base actions on them that are hardly warranted by the facts.

Before the values now used as interim guides can really be regarded as satisfactory standards, they must satisfy the following criteria:

1. The toxic material must be accurately known, any variations in reactivity well-recognized, and measurement accurate.
2. The modifying effects of other environmental conditions must be quantitatively known and susceptible to measurement.
3. Effects should be quantitatively predictable, at least for a specified "standard" person, and the ultimate social as well as biological consequences foreseeable.
4. Means should be available for predicting any modification of these effects for persons different from the "standard" by reason of age, activity, prior exposure, etc.
5. The limits of confidence of predictability should be clearly stated, having regard to all the sources of error in measurement, sampling, individual variability, and interaction of coincident conditions.
6. Finally, the prediction should be applicable to such time variables as duration, frequency, and course of exposure.

There is a lot of research to be done, a lot of information to be gathered, before we can begin to be satisfied with our standards. It is no longer sufficient simply to find out how toxic a particular substance is. We want to know why it is toxic, how it is used, what are the body's natural defenses, how can these be stepped up, and how can we avoid depressing them. Basic mechanisms must be studied in conjunction with the more routine toxicology. It's very interesting in the case of the pulmonary epithelium, which Fairchild and others have been studying, that they now realize that the essential mechanisms lie in the cell, that these mechanisms are affected by a number of things including the endocrine glands, and the sympathetic nervous system, and that they find themselves talking about precisely the same things as the people working on radiation. Far from confusing the issue, this makes both parties feel that they are really dealing with a fundamental mechanism, and are working at the right place.

Switching from the chemical environment to the physical environment, there is still a great deal to be known about the effects of heat on man. You may ask why, in view of the work that has been done, we don't know the answer. First, because in industry, the biggest heat contribution is very often from sources of radiant heat which are difficult to compute. Quite a bit of research is now going into the measurement of the study of radiant heat on man. Second, most of our data have been taken from healthy young male medical students of Army "volunteers". It is at least debatable that these two groups really represent people working in industry.

This we are now trying to rectify by studies of actual workers in hot industries.

A large number of environmental factors have been studied, but, for the most part, one at a time. Our problem now is to predict their effects when several operate at the same time. You can know how factor A works, how factor B works, how factor C works, but this does not tell you, and there is no logical way for predicting, how A, B, and C will work together. There has been a lot of talk about seeing the total man in the total environment, but how? There are those who think this can be done mainly by reliance on computers. I don't believe this. There are certain aspects which can be handled by computers and data which can be simplified, correlated, and presented by means of computers. But the total concept is something much more than the computers ever do. It can only be done by people using their own computers, their brains, which are very good computers for such types of work. By a cyclical process of meeting together, finding both common ground and deficiencies, going away and looking into unresolved facts, and coming back for further integration, the investigators can build up a composite picture. This is true throughout the environmental sciences; it is an objective which all of us have to work towards. Unfortunately, there is no logic set out beforehand for this; there is no pattern one can follow. One has to develop the rules as one goes along.

In our operations we naturally run into certain difficulties. The research man looks at things quite differently from

the industrialist and semantic misunderstandings arise. But this is breaking down; industrialist and research workers are getting more and more together. They are beginning to talk about the same things; they are dropping some of the mutual distrust stemming from mutual misunderstanding. We can help by consciously bridging the gap. The problem of industrial secrecy, on the other hand, is with us forever. If you are a manufacturer, you naturally don't want the guy next door to know what steps you are taking to get ahead of him. You are not about to disclose your plans to an outsider or even a PHS officer. This is only natural. Actually, we find management as helpful as can be expected. They do give us certain information on a person to person confidential basis. This can't be used, or cited, but it does increase our understanding and ability to deal with problems and perhaps even to foresee problems. Whether this confidence would continue if we were endowed with regulatory powers is debatable.

When it comes to applying our knowledge, we again run into some difficulty. The normal method is through State and local health agencies and from them back to the industries involved. Unfortunately, some State and local health authorities are, from our point of view, too preoccupied with other matters and are not geared to apply this information and use it as it should be used, let alone pass back information on how effective or ineffective it was or what problems are developing. Both our informational and our executive contracts with reality are restricted. A lot of thought is being

given at the moment of overcoming this. I hope something comes of it.

Finally, the very wide spectrum of competencies that we must draw upon, is itself a problem. There is hardly a medical or paramedical science that is not involved. This investment should be employed as widely as possible. While on the face of it, we are concerned with the worker at his place of work, there is no such animal. You cannot take a man at his place of work and consider him in isolation. He does not stop being mad at his mother-in-law when he comes in the gate, nor does he park his cold at the gate. His supervisor, his buddy and his work will suffer accordingly. This artificial barrier between the worker at work and the worker away from work must be crossed and crossed in both directions. The study of the worker started in the name of occupational health should be extended laterally to meet with those being conducted community-wide on air, water and food; in short, the total man in the total environment.

GENERAL DISCUSSION

One pertinent question asked dealt with the problem of noise. It was pointed out, by the questioner that we are getting more sensitive to noise every day and that we're living in the jet age and more and more mechanical devices which produce noise.

Dr. Lee pointed out that occupational health has become quite interested in noise, attempting to interest Congress in noise, but so far not moved beyond the Bureau of the Budget. To most people, of course, "noise" suggests deafness, loss of hearing. This is certainly a dramatic and important thing to the individual. A lot of work has been done but on the simpler aspects, but the position is more complicated than this. The noise can vary, not only in intensity, but also in the mixture of the various wave lengths, the frequency with which critical patterns are encountered, and the presence of relatively pure-tone spikes as it were in a lower level spectrum. We are studying the effect of all of these in producing temporary hearing loss. Audiologists apparently fall sharply into two groups. One group thinks that temporary hearing loss is a good index of the permanent hearing loss that would ensue if the noise were continuous. The other group doubts this. For lack of any other objective criterion, we are following the first. Apart from hearing loss there are two other aspects of hearing which the public are becoming more and more aware. One is the distracting effect of noise on a worker's ability to do some other task. People

complain. "I can't do this particular work" and "I can't add up figures", "I can't make correct entries", "I can't make this fine judgment", because there is a lot of noise going on. We are not sure how much is real or simply felt. You get some surprising results when you start making measurement. (Dr. Lee recited a war-time study to illustrate this point). We are just now setting up to study this aspect.

The third area is the sheer nuisance effect. Nobody likes noise or, conversely, noise is sound which nobody likes. And there is an awful lot of noise that we run into in the course of our daily activities which we don't like. Does this matter? It may affect property values and people are becoming less and less tolerant of stress, but does it really matter to the psychology of the individual, does it induce nervous tension and other kinds of disturbances? We don't know, and again we are trying to find out. We have collected noise samples at most of the major airports now and on highways around Cincinnati. These records are brought back to the laboratory and studied in some detail. This is the great advantage of modern technology, you don't have to make these studies in the field. You collect noises on the calibrated tape and bring it back and study it at leisure much more exactly in the laboratory.

RESEARCH NEEDS IN RADIOLOGICAL HEALTH
Dr. Arthur H. Wolff

The three basic areas to be considered in Radiological Health Research are: (1) exposure assessment; (2) control and reduction of dose; and (3) dose-effect relationships in groups exposed to low levels of radiation. Due to technical advances low level radiation detection is now possible with excellent precision and accuracy. It is in the third area where the biological significance of what is measured must be interpreted, that the most information is lacking and consequently this will be the subject covered.

It is known that certain deleterious effects are brought about from high or moderate radiation doses, but little is known concerning low dose effects to large populations. Much qualitative and quantitative information is necessary if we are to have an idea of the delayed sequelae which occur, or if standards are to be set in the low dose range. In the attempt to balance the risks and benefits of atomic energy, adequate evaluation of the risks of low level exposures are mostly undetermined.

Most research has concerned itself with acute radiation effects or long term effects of moderate to high doses, but the long term effects of low doses have been almost totally neglected and here is where primary radiological health research is needed. However, enough information is available to delineate the needs and a bibliography covering this information is available.

It should be emphasized that knowing the questions provides no assurance to knowing the answers. We know that the work to be done is time-consuming and expensive and will probably yield answers only through synthesized isolated bits of information rather than a "breakthrough."

The biological effects of radiation have been studied to a great extent but gaps are still apparent. A review of the knowledge of long term radiation effects, some of the knowledge gaps, and the complexities in filling these gaps were reviewed.

Major long term effects may be split into three categories: (1) somatic - those affecting the individual (carcinogenesis and aging acceleration); (2) genetic - those which will affect offspring because of parental gonad irradiation; and (3) congenital and in-utero - a special case of the preceding two.

In general, most of these effects are dependent on dose magnitude, but at low doses the shape of the dose-effect curve is conjectural and it is not known whether the phenomenon is one of threshold or non-threshold characteristics (genetic mutations are considered non-threshold). Damage which occurs at low doses may not be unique to radiation, and it is difficult to decide if radiation itself was the cause or an accelerator of any specific effect. As doses are lowered the frequency of long term effects decrease making the numbers to be studied statistically inordinately high.

Radiation does not behave biologically as a single toxic agent, and dose magnitude is only one of a complex interrelated set of variables (as an illustration, thyroid cancer decreases dramatically

in rats above a certain dose level). Other variables are:

(1) rate of exposure - generally, the more intense dose rates show more efficient production of effects; (2) types of radiation alpha, beta, gamma, and X-rays, etc., yield varying effects; (3) energy of radiation; (4) species variations; (5) strain variations; (6) individual variations - this includes sex, state of health, metabolism, and age (the young seem more susceptible); and (7) organ and tissue variations - the more mitotically active cells and tissues are most radiosensitive.

The reason for this listing is to point out that most work has been done on an over-simplified level without accounting for these many variables, e.g., the knowledge and the effects of I-131 and Sr-90 on humans has come about through studying X-ray and gamma exposures at much higher doses than would be received from these radionuclides. Also, work done with animals is not readily translatable to man.

The importance of these factors is to indicate the present state of knowledge and how future research may change. Most previous experimentations have been large scale human epidemiological studies looking for statistical differences in physiologic, pathologic, and morphologic changes as a function of only a few variables. The studies usually involve doses at a level much above environmentally received doses.

These traditional studies will not yield any ultimate low dose-effects relationships; the statistics alone make this improbable.

These studies would be more useful if more sensitive indices were available.

Research recently has been shifting to studies at the fundamental cellular and subcellular levels. Recent dramatic advances have now provided tools for work at this level. Much work is now underway concerning the interaction of radiation with cell enzymes, DNA, RNA, and various enzyme systems; and preliminary information suggests an underlying similarity in the cytogenetic and molecular mechanisms involved in radiogenic carcinogenesis or radiation produced mutagenesis and premature aging.

Hopefully then, molecularbiology, or studies at fundamental cellular levels, will provide the more sensitive indices needed to furnish insight on the threshold problem.

References have continually been made concerning the dichotomy between applied and fundamental research. Rather the distinction should be between bad and good research, for only the latter will give answers.

DISCUSSANT
Dr. Harold Zallen

Problems and projects in the three areas of radiological health research were discussed: These were exposure assessment; control and reduction of dose; and dose-effect relationships.

Some of the approaches to long period effects of low level exposure which are now being, or soon will be, carried out are: (1) the PHS milk sampling and air sampling networks; (2) X-ray exposure histories data; (3) the whole body human counter - good low level results are achieved but the cost is high; and (4) the whole body liquid scintillation counter - an instrument capable of measuring natural levels of radiation with high sensitivity. All of these are complicated procedures and the large samples and long times required mean high expense.

In regard to I-131, it is suggested that the Proceedings of the Hanford Symposium on the biology of Radioiodine, published in the December 1963 issue of the Journal of Health Physics Society (Volume 9), be read.

A classic radioiodine study is the Windscale Incident. In October of 1957, the United Kingdom's plutonium plant overheated and created a uranium fuel fire. Radioisotopes were released. Authorities immediately concerned themselves with I-131 and down-wind assessments were made. Cattle pastures showed significant levels. The result was that 250,000 gallons of milk were condemned over 300 square miles, involving 100,000 people. The level at that time was 0.1 microcurie per liter of milk. Data from this

incident indicated that levels as low as 150 rads could be associated with thyroid cancer incidents in the order of 1%.

Much work is being done on radiation effects at the macro-molecular level including work on DNA and RNA. At the PHS Laboratory in Rockville, Maryland, such work is being done using ultraviolet absorption spectra as an analytical tool.

Work must be done with the various emissions at varying energies, particularly in the MEV range.

In summary, some of the fields of ultimate investigation which may be explored are: (1) low level exposure instrumentation, including solid state detectors; (2) biological correlation with physical data; (3) perfections of low level chemical dosimetry; (4) new ideas for personnel dosimetry; (5) relationship of particulate sizes with biological intake, (6) improvements in low level bioassay; (7) the use of gas liquid partition chromatography and the use of electron capture head. These are a few of the possibilities.

GENERAL DISCUSSION

Dr. Wolff began by re-emphasizing his point on the difficulty of relating environmentally received low doses to their supposed effects by pointing out the following about the Windscale Incident. The combination of small dose and small population group could easily point to the fact that a 1% occurrence of thyroid cancer could have been either X-ray induced or even natural; one case of X-ray cancer of the thyroid would make all environmental data meaningless. It is impossible to isolate variables in epidemiological studies.

In answer to a question put to him by Dr. Letson, of Georgia Tech, concerning long term-low dose research, Dr. Wolff noted the dog studies at both Colorado State University and the University of California, and the many rodent studies as current projects. The reasons for the apparent neglect of this field are the difficulty in obtaining long term support money, the basic unattractiveness of long work, and the inability to publish often. The AEC is willing to support long studies but takers are few.

Dr. Krenkel, from Vanderbilt University, suggested that those who give money for research admit to a need for applied work but consistently turn down those applications in favor of basic research.

Dr. Palmer Saunders, National Institute of Health, countered by saying that the statement wasn't quite true; that much money has gone out for work in the applied field.

Dr. Zallen commented that the terms applied and basic involve semantics but that originality is the point to be considered.

U. S. Grant Kuhn, III said that sensible or realistic standards should be set and that these involve only from the search into the toxicology of potential innocuous agents in the environment.

The fact that all research is, in reality, a combination of applied and basic was pointed out by Mr. Irving Gerring, of the National Institute of Health.

A grave concern is the trend of universities to turn out people with advanced degrees whose knowledge is very great in a limited field; as a result they are unable to relate their work to anything and their use is limited.

Dr. Wolff, in answering a question of Mr. Payne's, said that some work has been done in developing a biological dosimeter.

Summary
RESEARCH NEEDS IN FOOD PROTECTION
Dr. Keith Lewis

Dr. Keith Lewis in his paper delineated the multiplicity of needs brought about by advances in food technology and discussed research developments of the Robert A. Taft Sanitary Engineering Center at Cincinnati, Ohio. Dr. Lewis indicated that less than 10% of the \$130,000,000 that is spent on food research each year goes into research directly related to food protection. The approximately 90% remaining is devoted to agricultural improvements and marketing techniques. Subsequently, there is no indication that the prevalence of food-borne illnesses has declined in the United States during recent years. This index of the prevalence of food-borne illnesses has led a number of professional groups to urge coordinated national effort. In summary, Dr. Lewis pointed out that in relation to public health there is a need for technical information in the following areas of food protection:

- a) Improved recognition, investigation and reporting of food-borne illnesses.
- b) Selection of criteria for detection of potential health hazards in commercially prepared foods.
- c) Improvement, evaluation, and standardization of methodology.
- d) Modernization of food protection programs and practices.

e) Extension of basic knowledge about health hazards associated with foods.

Dr. Hamby in his discussion of "Research Needs in Food Protection" advanced the need for research in foods contaminated by radionuclides. He directed attention to the 12 outbreaks of botulism in which 14 persons died, to indicate the need for rapid detection of pathogenic organisms and/or their toxins implicated in food-borne diseases.

Summary
DISCUSSANT
Dr. M. K. Hamby

Dr. Hamby disclosed that in food research being conducted at the University of Georgia, School of Food Technology, S. aures isolated from poultry feed has also been isolated from the bruised tissue, gut, air sac, skin of poultry, and chicken droppings. Bruised tissue may be a source of contamination to other birds and a health hazard to workers and consumers. In order to obviate the health hazards presented by bruised poultry, Dr. Hamby pointed out the need for education of poultry growers in better handling techniques, and the need to eliminate external sources of contamination.

He further pointed out that chemical contamination of food is increasing due to the increased use of pesticides, weedicides, and chemicals used to combat plant and animal diseases. Dr. Hamby proposed the self-regulation of food and chemical industries and extensive Federal laws which require extensive testing of pesticides and food additives.

GENERAL DISCUSSION

The resulting general discussion brought out the following needs:

- 1) The need for continued research of diseases transmitted by shellfish.
- 2) The need for regular sampling of food products for pathogens and toxins.
- 3) The need for immediate and long-range testing for various pesticides.

RESEARCH NEEDS IN DRINKING WATER
Mr. Harry P. Kramer

The greater and greater reuse of water in this Nation has made it imperative that research supply the key to an assured supply of water of quality suitable for all our needs. Water treatment and wastewater treatment can only become ever more intimately interrelated because of this greater use and reuse of a fresh water supply that is essentially constant. This viewpoint limits the role of dilution in helping us to provide drinking water of the specified desired quality, because the value of good water is too great to permit its use to dilute wastes. In essence, dilution can only become less effective as demand for water increases.

The quality objectives which the profession places upon itself are listed in the drinking water standards. These, we realize, must be greatly amplified, that is, made much more meaningful. Only through an expanded research effort can we hope to make such standards rest more upon scientific fact and less upon purely judgmental factors, important as these will continue to be, and to enlarge their scope to include all the chemical physical and biological agents that may be found in water supplies.

. It has been said that only one chemical element, fluoride, found in water supplies has been intensively studied. Interestingly, in this case, the beneficial effect to the human body

has been established by research to be closely related to a very minute quantity of intake. The incidence of dental caries increases most significantly when amounts less than the optimum are present. Natural waters containing amounts above the optimum produce mottling of the teeth, and water treatment methods had to be developed to reduce the concentration to the optimum range. Many other elements could be subjected to the same intensive study; they offer a tremendous field for research. We already have a number of indicators which plead for investigation, such as the role of vanadium in heart disease, and what is the answer to the low-hardness high-heart-disease riddle? Is sodium in this context independent of or related to other chemical factors? Here the opportunities for research occur in the epidemiological, toxicological, and pharmacological areas as they concern drinking water quality, and they are truly vast. Making a naturally complex situation even more complex is the fact that rational levels must embrace the insult or benefit to man from the other environmental channels of air and food. Standards should comprehend the body burden of significant substances in their relationship to the health of man. It is in this health aspect that our greatest research need lies.

As a basis for such studies a greatly increased capability in analytical methodology is required. This applies not only to the complex organic materials both natural and synthetic which concern us, but also to the inorganic substances. Their chemical

form, as found in water, is often of paramount importance. We are developing the capability of measuring smaller and smaller concentrations of these substances. Yet the obstacles to successful analysis posed by the presence of interfering substances in drinking water yield most grudgingly to all the artful approaches the chemist has devised. This situation begs us to explore, much more rapidly, the revolutionary developments occurring almost constantly today in the analytical field. In cases where increased sensitivity is required, much larger samples can be collected and subjected to stripping procedures which have been found effective, through research, for concentration. For whatever standards are adopted, the associated analytical methodology should be continuously subjected to referee or reference-testing to insure the accuracy of the data the method is expected to provide. Our capability in collecting some significant fraction of the mixture of dissolved organics from water has not been paralleled to the same degree with our ability to separate and to identify the molecular species present in the crude extract. The ability is within reach to detect accumulation, if it occurs, of waterborne synthetic organic chemicals in the tissues and perhaps even in the blood of water consumers. Furthermore, an interesting and important question concerns the possible occurrence, and effects, on the public of the trace residues of the many new, powerful drugs now used almost universally, - the steroids, hormones, and the psychergic drugs, for example. Further water works must not

wait for the simple inexpensive procedure before involving themselves intimately with the definition and measurement of what is in their product. Admittedly, expensive equipment and competent personnel are required. Water is our most important food product and the need for the water plant to measure quality and to seek out means for the improvement of water quality cannot be deferred in the hope that cheap and convenient techniques will become available. As is being said more and more, good quality water is going to cost more.

Nor, as we well know, has our classical criterion of water quality the microbiological factor been static. The rapidity with which new enteric viruses are being described reemphasizes the potential problem of waterborne virus disease. In 1948 the viruses producing poliomyelitis and infectious hepatitis were known to be present in human feces. From these two viruses the number has now grown to nearly a hundred. Many of these have been detected in urban sewage. We still have a pressing need for the development of a laboratory technique for cultivating and identifying the virus of infectious hepatitis. Techniques for concentrating small amounts of virus from large amounts of water would be invaluable. Much more information is needed regarding control or inactivation of viruses by chlorination and by other means. Is there a better "indicator micro-organism" to measure pollution than the coliform group? The coliform and fecal streptococcal groups constitute only a very small minority of the types of bacteria in the feces of warm-blooded animals.

Free-living nematodes, protozoa, and especially rotifers and oligochaetes, are chiefly bacteria feeders, members of the ecological system involved in aerobic sewage treatment. Nematodes and protozoa are relatively resistant to conventional chlorination; thus they may appear in finished waters. The possibility of nematodes as carriers of human enteric pathogens has already been demonstrated in the laboratory, and the problem of nematode control in water supplies is still a research challenge.

Since it has not been shown that industrial contaminants have any known beneficial effects, and even though we may currently lack strong evidence that they have direct harmful health effects, such materials are rightfully suspect. These contaminants do cause serious taste and odor problems in finished waters and a host of effects in the river water itself, such as damage to aquatic life and foaming. Should not all organic materials be removed from drinking waters? When orthonitrochlorobenzene was found in the Mississippi River at New Orleans, it was traced 900 miles north to its origin at St. Louis. The material, essentially undiminished in concentration, appeared in the drinking water at downstream communities. Fortunately, the concentrations were less than the toxic level of 0.05 ppm. This contaminant did not make itself evident in the drinking water either by taste or odor; yet it was present. Ordinary water treatment processes do not affect it. Activated carbon can remove it. Have we not reached the point where all municipal supplies which

use industrially polluted waters should employ carbon treatment as a standard practice? Extremely small quantities of certain materials can cause severe effects; for example, parts-per-billion levels of insecticides and other organics have killed fish and have produced taste and odor effects.

While carbon is highly effective, its application is not a magical cure-all. Greater knowledge is needed in the economics of using adsorbents and oxidants in removing organics of all types. Only research can provide the scientific basis and elucidation of the phenomena underlying each of the currently employed processes, including coagulation and filtration. We must make treatment more a scientific practice than an art. Our attention has been called to the valuable opportunities we have to conduct a much greater level of research in the treatment plants themselves. Plants are now designed to provide the treatment required to meet the standards, but is this enough? Should not the unit processes be immediately and automatically responsive to changes in raw water quality? The more sensitive the relationship, the more secure will be the attainment of the specific quality.

The buildup of inorganic solids through water reuse calls for demineralization techniques. This goes beyond the reduction of hardness. Such an objective is obtainable through application of advanced processes that are both reliable and reasonably economical. The reduction of such substances can be tailored to the level desired. If distilled water is produced, blending with

mineralized waters enables attainment of a water of any desired mineral quality. This reaffirms a dominant research need mentioned earlier - what specific materials at what levels should be permitted in drinking water?

We must be prepared, if necessary, to take water containing any type of dissolved impurity and produce a high-quality drinking water. Our attention, therefore, should not be restricted to the source of the drinking water and to the processes to which this water is subjected. Contamination of treated waters can and does occur in distribution systems. Organic growths which establish themselves in such systems contribute taste and odor, biological contamination, and other objectionable effects. Research is required to elucidate the conditions which foster such deleterious effects upon drinking water quality and to provide the most effective as well as practical control measures.

Ground waters pose many research problems identical in nature to those encountered in surface waters; in addition, they present unique challenges. The relationship of soil-water properties to water quality needs greater exploration. The occurrence of detergents in ground water supplies in many parts of the nation is an example of this type of problem. The soil after all offers a medium for the treatment of impurities in the percolating water. How can we take practical advantage of such natural purification phenomena to protect the quality of the ground water supply?

The problems I have been discussing are, of course, not new,

but the fact that they are known to us does not minimize their importance. Is it not frustrating that, despite our use of water treatment processes well-known to us for 50 or more years, we must still admit a lack of full understanding of the phenomena that occur? Here is an obvious and long-standing research need.

But of this we can be sure. Even with full understanding of the processes, they will certainly not be effective in the correction of many of the newer insults to water quality. Our recognition of this situation provides the opportunity for the exercise of imagination, creativeness, ingenuity, and boldness in coping with the problem.

The challenge facing the scientist and engineer in water treatment research is greater now than at any time in our history.

Summary
RESEARCH NEEDS IN DRINKING WATER
Mr. Harry P. Kramer

Studies need to be made on: (1) the reuse of water; (2) plans to place all standards of water quality on a scientific basis; (3) to enlarge analytical chemical capability in evaluating water quality and the health effects of accumulation of specific substances in humans; (4) to continue biological research on viruses, protozoans, bacterial indicators and biologic standards; (5) a study of the desirability of removing all organic materials from drinking water; (6) to develop demineralization processes; and (7) to study means of the protection of water in distribution systems after plant treatment.

This year work at the Sanitary Engineering Center will focus on the multi-problems of virus detection, enumeration and identification in drinking water with plans to establish limits for the next edition of the Drinking Water Standards. At least eight professional personnel will work on water virology, chemistry and toxicology. Work will also be done on eleven additional trace elements found in water for which limits have not been established and their effects on health not known. Some, such as vanadium, may have beneficial effects. The fields of trace element chemistry, mycology and physiology needs to be intensively investigated.

RESEARCH NEEDS IN WASTE WATER

Dr. Leon Weinberger

Waste water problems have been defined in the past, but we are now looking for different solutions. The differences between water treatment and waste treatment research problems are minimal. The type of researchers needed include chemists, physicists, biologists, medical scientists, and mathematicians in the scientist category; sanitary, hydraulic, and chemical engineers in the engineer category; together with social scientists, economists, sociologists, and political science men.

Research needs may be classified into six categories:

- I. Identification and Measurement of pollution.
- II. Determination of effects of pollution on water quality and water use.
- III. Treatment of waste and contaminated water.
- IV. Disposal of waste effluents.
- V. Control of wastes at their source.
- VI. Water management including stream flow for pollution control.

In waste water research it is necessary to carry out theoretical work, laboratory work, pilot plant work, and full scale plant work. Research in the past has not been effectively translated into practice.

(Research Area I) - Present methodology for detecting and measuring pollutants - is deficient for both organic and inorganic

biological contaminants. To assess the water pollution problem and devise effective programs for controlling pollutants, development and application of new and more effective analytical methods are needed. Need exists for different methods to identify the same material since accuracy and control needed in the field and the laboratory differ.

Some analytical methods can now report results in nanograms per liter. Analytical problems associated with these low levels of concentrations are enormous.

Methods are needed to measure total carbon or total organics to indicate what is gross pollution. The carbon adsorption technique is just a step in trying to arrive at a suitable technique. The ability to identify the source of a pollutant would be helpful in control work as to whether it originated at a natural, industrial, or a municipal source.

(Research Area II) - Effects of pollution on water quality and water use is another way of talking about standards. Standards should be thought of in two ways, in terms of water use and in terms of stream use. In terms of effects of pollution on water quality and water use, all water uses industrial, recreational, fish and aquatic, wildlife, and agricultural must be considered. In this area, better epidemiological techniques are needed to more clearly indicate the relationship between impurities and health.

More research in the socio-economic aspects of water pollution is needed.

A better understanding of the toxicological mechanism of organic and inorganic pollutants is needed since evaluation of the toxicity of new chemicals cannot presently be done at a rate to equal the introduction of these pollutants to the aquatic environ. The need exists for a better understanding of enzyme reactions as well as membrane technology as related to the living cell. We need techniques for measuring sublethal long range chronic effects on aquatic life of pollutants. More understanding of the critical step in the fish food chain is needed.

Work in regard to the persistence of pollutants is needed, whether these be pesticides, detergents, or any organic material. More knowledge of how these materials interfere with water or waste treatment processes is needed. What is meant by practical, feasible, or reasonable in terms of cost of water and waste treatment need re-evaluation.

(Research Area III) - Treatment of waste and contaminated water means a better understanding of all the unit processes currently in use is needed, plus the need for new or nonconventional treatment. The problems of polyelectrolites, zeta potential, and new approaches to waste treatment problems of low temperature are ideas in which we need research.

Advanced waste treatment includes new methods as well as those methods of treatment not in common use. In some areas, treatment devices commonly used are not adequate

or the community affected may desire to reuse its waste water. The end product of highly effective waste treatment is water of a relatively high quality and is a valuable and usable by-product of pollution control. The process should be economical. Some of the advanced unit operations being studied are: foam separation, electro dialysis, freezing, adsorption, evaporation, and reverse osmosis.

(Research Area IV) - Disposal of waste effluents needs continuing work in the fields of disposal in soils, surface waters, fresh surface waters, and marine waters. Many questions concerning the assimilative capacity of streams are still posed.

(Research Area V) - The control of wastes at their source. Pollution sources can be divided into the two categories of point and non-point sources. Point sources are the municipal and industrial wastes that are collected in a single sewer or interceptor sewer and then receive treatment in a plant. Drainage from rural and urban land is considered to be non-point sources. Pollution from land drainage in urban areas is much more significant than previously thought.

The problem of eutrophication may very well be associated with the matter of land use control as related to water pollution. Pesticide application is also related to pollution from land sources. More work is needed in industrial waste elimination, waste recovery, and by-product utilization.

(Research Area VI) is concerned with water resource management including regulation of a streamflow for pollution control.

In many parts of the country, sufficient dilution water is not available at times of low streamflow to afford sufficient dilution to wastes even though the wastes have been afforded complete treatment. Additional dilution water may be supplied by impoundments and streamflow regulation. However, the impoundments themselves often create considerable problems. The whole matter of impoundment in general requires considerable research and the subject of multiple use of impoundments is something that needs additional work.

In conclusion, the two greatest research needs are:
(1) increased research at all levels and (2) more qualified researchers. Unless people are available who are going to be working on the problems outlined here the needed work indicated is just more work which will not be done.

Summary
DISCUSSANT
Dr. L. G. Rich

Generally, there are three areas of major importance to which more research-oriented attention should be paid. The first of these is concerned with the parameters used to evaluate treatment process performance, and reference here is not made to water quality parameters but to parameters used to evaluate waste treatment process performance. Continued use of BOD and COD parameters when new and relatively sophisticated processes are being incorporated in treatment technology is not acceptable. While BOD may serve as a measure of organic pollution, it fails as a parameter which can be used to predict the performance of a treatment process, the removal mechanism of which is totally unrelated to the biological oxygen avidity of the waste being treated. The same can be said of such parameters as COD, solids, nitrogen, and what have you. Processes being developed as advanced waste treatment systems require better parameters to evaluate their processes.

The second major area of importance needing research efforts relates closely to the first. The efficient use of new, more sophisticated processes requires more detailed knowledge of waste characteristics than is presently available. The use of a process parameter is effective only when the waste property related to the removal mechanism of the treatment process is identified and measured. A complete analysis of the waste is

not suggested; however, more attention should be directed to the characterization of wastes in terms of particle-size distribution, polarity, zeta-potential, and other properties that may relate to the removal mechanism of our individual treatment process.

A third area of research needs encompasses the field of process engineering application to waste treatment. The need exists for the study and application of new concepts in process engineering equipment. Process engineering would do more to revolutionize waste treatment than all progress made in the fields of chemistry and biology.

There is a need for reappraisal of conventional processes in light of contemporary knowledge and the application of new instrumentation.

GENERAL DISCUSSION

More work in the area of information storage and retrieval is needed. The gaps between disciplines need to be breached and dispersal of existing information within these disciplines needs to be more widely disseminated.

Instead of writing off part of the cost of dam construction for pollution control, it may be possible to spend the equivalent of the money involved or a fraction thereof, to develop better methods of sewage treatment so that the material can then be discharged into a stream and require no dilution water.

Mineral nutrient constituents of effluents from waste treatment plants, even those affording complete treatment, markedly alter the waters of lakes and impoundments. As an example, people living near a highly turbid reservoir may complain about the turbidity, but how seriously will they object to the algae that will readily grow once the turbidity is removed? What is our relationship to water and water use? The cities cannot be moved and the monetary outlay will be enormous if all pollutants are expected to be removed from waste discharges to protect impoundments.

Some lower degree of statistical chance must be used other than the present standard of close to 95 percent safety limit if we are to be realistic in the relationship of tax structure

which we anticipate or demand that the city provide in order to reduce pollution. We need to find engineers and governmental agencies willing to accept responsibility of adopting research accomplishments made in the past.

It should be possible to scientifically predict the level of pollution that produces no effect.

It must be known to what extent the public is willing to absorb increased taxes for waste treatment or for water treatment.

Nutrient removal from waste water is being investigated. If waste water is to be reused as drinking water, some better, more economical means of treatment must be developed.

Summary
RESEARCH NEEDS IN SOLID WASTES
Dr. R. J. Black

The American Public Works Association reports that the annual cost to American cities of refuse collection and disposal at from 1.5 to 3 billion dollars and this is exceeded only by the cost of education and highways.

Refuse collection and disposal must be conducted without creating health hazards and nuisances. The explosive growth of our cities, expected to double in population by the year 2,000, with increasing per capita production of solid wastes, presently find that suitable land for disposal of wastes is running out. Land suitable for waste disposal is also in demand for other more attractive uses.

Incineration offers one attractive method for refuse disposal of combustible waste; however, up to 25% of the volume fed into incinerators shows up as ash and nonburnable material that can be attractive to vermin. This method has the most attraction for large cities where part of the fuel used to burn wastes can be recovered for heat or power production and where land for disposal of wastes is very limited.

Composting of solid wastes is a recent method of disposal attempted in the U. S. and depends to a great extent upon a market for a quality fertilizer product. With this method there is again produced a waste product of noncompostable materials,

such as glass, metals and plastics that may reach 25% of the total. This must be disposed of by landfill.

The "Gross Report" lists 24 areas of needed research in solid wastes classified as basic, operational, and administrative and these were assigned recommended priorities. However, research expenditures for solid waste have been pitifully small. There is, however, indication of a growing interest in research and the solving of problems in solid waste disposal, as evidenced by numbers of items listed in the series of annotated bibliographies on this problem prepared by the Division of Environmental Engineering and Food Protection, a doubling of items listed from 1958 to 1961. The present choice of burn and/or bury is not a solution to this pressing problem. It is hoped that composting can offer further assistance in a choice of methods.

CONFERENCE SUMMARY
Mr. F. A. Butrico

In considering a summary for this Conference on Environmental Health Research Needs, I decided against a review of the many specific research items which were presented by the speakers. Instead, I will try to generalize and indicate some implications of what has been said and, in the process, I am sure, inject some of my own ideas on the subject.

In listening to each speaker, it was interesting to note that, regardless of the subject, each referred to similar words and phrases to explain research needs in specific program areas and related subjects of manpower and training. These "key words and phrases" in various groupings will serve as the summary.

Frequent reference was made to the words and phrases, "toxicity" "synergistic reactions," "interactions of the many factors of the environment," "methodology," "biological effects," "social sciences," "applied research," "basic research," "fundamental research," "manpower," "interdisciplinary approach," "total man," "total environment," "public awareness," "environmental insults," "economics," "single-agent insults," "chemical agents," and "physical agents."

Grouping "toxicity," "methodology," "social sciences," "public awareness," and "environmental insults," we could summarize the general areas of fruitful research needs in environmental health into about four categories: (1) human

ecological studies to establish "norms" - that is, the qualitative and quantitative measurement of normal physiological, neurological, behavioral, and sociopsychological responses to stressors or stimuli prevalent in an environment free from technologically induced perturbations; (2) direct research inquiries into the determination of biological effects associated with environmental insults; (3) inductive type research aimed at generalizing for a population (community, socio-economic strata, occupational group, geographical cluster, etc.) the impact of environmental insults from an analysis of a host of singularized data; and (4) research in establishing pre-clinical sensors designed to signal the subtle, cumulative, long-term effects of environmental insults, singularly or in synergistic combination.

Considering the research needs in environmental health as expressed by the terms "inter-action," "total man," "total environment," "chemical agents," "physical agents," and "single-agent insults," it is evident that there is an inter-relationship among the environmental health problem areas. The environmental health hazards we seek to prevent or control do not necessarily assert themselves as a "single-agent insult." There is need to consider the total combined effect of our modern environment on man, that is, assessing the impacts of contaminants associated with air, water, food, and soil, along with the social, physiological, and economic factors. As Rene Dubos of the Rockefeller Institute has stated, "Unquestionably, the doctrine of specific etiology

has been the most constructive force in medical research for almost a century...in reality, however, research for the cause may be a hopeless pursuit because most disease states are the indirect result of a constellation of circumstances, rather than the direct result of single contaminant factors."

Many of the present environmental health problems involve exposure of man to potentially harmful chemicals and physical agents. The exposures may occur as a result of air or water pollution, food contamination, occupational exposure or from a combination of these sources. Although the source of exposure, the route of entrance of the substance into the body, and the nature of the injurious material may differ, the underlying problem in each case is essentially the same, that is, impairment of health through interference by chemicals or radiation with normal cellular functions. A common denominator does exist for environmental health problems arising from any type of exposure to toxic chemicals and radiation.

The word "economics" was used frequently by the speakers. The complexities of our society have made it necessary that consideration be given to a host of factors, other than health, and such as economics in the decision-making process. The general public, as well as those who influence public policy, must be kept informed and aware of the potential environmental health hazards and the resources needed to cope with them. Only in this way will support be forthcoming and proper priorities given on the expenditure of public funds.

Many of the speakers referred to the need for "better communications." This is extremely important in view of the voluminous amount of technical information coming out of our research effort which should be made available to other scientists and to those in operations and teaching. There is need for scientist-to-scientist communication, and between professional workers, the general public, government, and industry. No one gains when communications among these groups fall down. Particularly, the situation is disastrous when the public is exposed to conflicting viewpoints and contradictions from the "professionals."

We in the Public Health Service have been giving some attention to scientist-to-scientist communication in environmental health research.

Within the Bureau of State Services (Environmental Health) there is being established a centralized system of automatic data processing for information retrieval and data storage. It is anticipated that this information will be helpful in improving communication among scientists by making available data on on-going research supported by the Public Health Service and other agencies reporting research information to the Science Information Exchange. The system is being made compatible with others - Medlars and ASTIA (now the Defense Document Center) - so that an exchange of information will be possible among systems. We expect that this system will be operational in about one year and will include publishing

regular reports on research underway, along with the names of principal investigators and the institutions involved, as well as a selective dissemination of information program so that specific research data can be furnished to individual scientists.

Reference was also made to "manpower" and "inter-disciplinary approach." Manpower needs included the electronic specialists, engineers, molecular biologists, those in paramedical sciences, meteorologists, systems analysts, social scientists, chemists, and mathematicians, among others. It is evident that the very nature of the environmental health problems makes an inter-disciplinary approach to research and training in environmental sciences an absolute necessity. The "professional team" working in this broad field for the identification of problems, research, design, and for the control of the environment and teaching must include highly and broadly trained individuals of the type mentioned. Thus, the intellectual resources upon which environmental health may be expected to draw are extremely broad and extend well beyond those which have been traditionally required in public health. The effectiveness of the Nation's effort in this field depends upon the availability of competent personnel in sufficient numbers to meet the task we face. To comprehend these ideas and to be able to adapt to the swiftly changing scientific environment will require post-graduate education of personnel

through the doctorate and post-doctorate level. The need for highly trained research scientists in public health has been pointed up by many committees, including the Engineers Joint Council Research Committee and the President's Science Advisory Committee.

There was also discussion about "conference" and "laundry lists of research needs". A review of the literature resulting from conferences would reveal many pronouncements on research needs and those areas which should be given priority attention. Unfortunately, at least to my knowledge, there is no mechanism whereby periodically there is a review of these research needs against the research actually going on. This is needed if the maximum benefits are to be derived from the research effort in environmental health.

Lastly, there was considerable attention given to definitions of basic, applied, and fundamental research. Those of you who heard this discussion can conclude with me that no decisions were reached. Suffice it to say that we need research in each of these categories by whatever definition one uses. Also, since reference was made to the attitude of the PHS in supporting these types of research proposals, I can assure you that our policies do not preclude favorable consideration being given to scientifically sound proposals in each category.

Each of us has a responsibility in furthering the research and training effort in the environmental health field. There is

a responsibility on the part of universities to carry on scientifically sound research in the areas of need, a responsibility of those in operations to apply the knowledge that has been gained in problem solving, and a responsibility for those in decision-making positions to make funds available to support research and training.

AGENDA

Tuesday, January 28, 1964

- 8:30 Registration
 - Chairman - H. W. Chapman
- 9:00 Welcome - H. B. Cottrell
- 9:10 Objectives of the Conference - T. W. Haines
- 9:20 Research Needs in Environmental Health Sciences -
Frank A. Butrico
W. M. Upholt
- 9:40 Questions and General Discussion
- 10:00 Break
- 10:20 Research Needs in Air Pollution - A. C. Stern
- 10:50 Discussion - E. R. Hendrickson
- 11:00 Questions and General Discussion
- 11:30 Lunch
- 12:30 Research Needs in Occupational Health - D. H. K. Lee
- 1:00 Discussion - H. K. Sessions
- 1:10 Questions and General Discussion
- 1:40 Research Needs in Radiological Health - A. H. Wolff
- 2:10 Discussion - Harold Zallen
- 2:20 Questions and General Discussion
- 2:50 Research Needs in Food Protection - K. H. Lewis
- 3:40 Discussion - M. K. Hamdy
- 3:50 Questions and General Discussion

Wednesday, January 29, 1964

Chairman - R. E. Stiemke

- 8:30 Research Needs in Drinking Water - H. P. Kramer
- 9:00 Discussion - A. P. Black
- 9:10 Questions and General Discussion
- 9:40 Research Needs in Waste Water - L. W. Weinberger
- 10:10 Discussion - L. G. Rich
- 10:20 Break
- 10:50 Research Needs in Solid Wastes - R. J. Black
- 11:20 Discussion - F. E. Gartrell
- 11:30 Questions and General Discussion
- 12:00 Conference Summary - F. A. Butrico
- 12:30 Adjournment

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